Copy of Allowed Claims

The Claims

1-11 (cancelled)

12- 17 (cancelled)

18-19 (cancelled)

20. (previously added) A method for measuring concentrations of water in a flow of an oil, gas and water mixture, said method comprising the steps of

directing a flow of a mixture of oil, gas and water through a pipe having an excitation coil around the pipe and a detector coil around the pipe in axially spaced relation to the excitation coil, said detector coil having a different resonant frequency from the excitation coil;

applying an alternating voltage to the excitation coil at a frequency of up to 20 MHz to induce a variable magnetic field in the mixture;

registering a resultant detector voltage in the detector coil as a measure of the electrical conductivity of the water in the mixture independently of the fractions of oil and gas in the mixture;

comparing the resultant detector voltage in the detector coil against a calibration value to determine the concentration of water in the mixture.

21. (previously added) A method as set forth in claim 20 where the alternating current applied to the excitation coil is in the range of from 5 to 15 MHz.

22. (previously added) A method for measuring concentrations of water in a flow of an oil, gas and water mixture, said method comprising the steps of

directing a flow of a mixture of oil, gas and water through a pipe having a pair of excitation coils around the pipe and a detector coil around the pipe between the excitation coils;

applying an alternating voltage to one of the excitation coils at a frequency of up to 20 MHz to induce a variable magnetic field in the mixture;

applying an alternating voltage to the other of the excitation coils at a different frequency of up to 20 MHz to induce a variable magnetic field in the mixture;

registering a resultant induced voltage containing two frequencies in the detector coil as a measure of the electrical conductivity of the water in the mixture independently of the fractions of oil and gas in the mixture;

detecting the amplitudes and frequencies of the induced voltage for comparison to a mathematical model to determine the concentration of water in the mixture and the conductivity of the water in the mixture.

23. (previously added) A method as set forth in claim 22 further comprising the steps of plotting the induced voltage as a function of the concentration of water in the flowing mixture to determine an abrupt decline in induced voltage with increasing water concentration as a boundary layer between a water-continuous phase containing oil droplets in water and an oil-continuous phase containing water droplets in oil.

24. (previously added) An apparatus for measuring concentrations of water in a flow of an oil, gas and water mixture, said apparatus comprising

a pipe for conveying a flow of a mixture of oil, gas and water;

an excitation coil around said pipe;

a detector coil around said pipe in axially spaced relation to said excitation coil, said detector coil having a different resonant frequency from said excitation coil;

an oscillator for applying an alternating voltage to said excitation coil at a frequency of up to 20 MHz to induce a variable magnetic field in the mixture;

a voltage detector for registering a resultant detector voltage in said detector coil as a measure of the electrical conductivity of the water in the mixture independently of the fractions of oil and gas in the mixture;

means for comparing the resultant detector voltage registered in said voltage detector against a calibration value to determine the concentration of water in the mixture.

25. (previously added) An apparatus for measuring concentrations of water in a flow of an oil, gas and water mixture, said apparatus comprising

a pipe for conveying a flow of a mixture of oil, gas and water;

a pair of excitation coils around said pipe;

a detector coil around said pipe between said excitation coils;

a first oscillator for applying an alternating voltage to one of said excitation coils at a frequency of up to 20 MHz to induce a variable magnetic field in the mixture;

a second oscillator for applying an alternating voltage to the other of said excitation coils at a different frequency of up to 20 MHz to induce a variable magnetic field in the mixture;

a voltage detector for registering a resultant induced voltage containing two frequencies in said detector coil as a measure of the electrical conductivity of the water in the mixture independently of the fractions of oil and gas in the mixture;

means for detecting the amplitudes and frequencies of the induced voltage for comparison to a mathematical model to determine the concentration of water in the mixture and the conductivity of the water in the mixture.

26. (previously added) An apparatus as set forth in claim 25 further comprising a steel housing having each of said excitation coils and said detector coil therein, said housing being disposed about said pipe.

27. (new) An apparatus for measuring concentrations of water in a multiphase flow containing water, said apparatus comprising

a pipe of electrically insulating material for conveying a flow of a multiphase mixture containing water as the only electrically conductive phase;

an excitation coil around said pipe;

a detector coil around said pipe in axially spaced relation to said excitation coil, said detector coil having a different resonant frequency from said xcitation coil;

an oscillator for applying an alternating voltage to said excitation coil at a frequency sufficient to induce a variable magnetic field in the mixture;

a voltage detector for registering a resultant detector voltage in said detector coil as a measure of the electrical conductivity of the water in the multiphase mixture independently of the remaining phases in the multiphase mixture;

means for comparing the resultant detector voltage registered in said voltage detector against a calibration value to determine the concentration of water in the multiphase mixture.

28 (new) An apparatus as set forth in claim 27 wherein said oscillator applys an alternating voltage to said excitation coil at a frequency of up to 20 MHz to induce a variable magnetic field in the multiphase mixture.